U.S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

569

Contribution from the Bureau of Animal Industry, A. D. Melvin, Chief.
March 21, 1914.

IMP. BUR.
9 MAY. 1914
ENTOM.

TEXAS OR TICK FEVER.

By JOHN R. MOHLER, V. M. D., *Chief of the Pathological Division.*

INTRODUCTION.

Texas fever, a very serious obstacle to the cattle industry of the South, has been pretty thoroughly understood since the investigations made by Smith and Kilborne, of the Bureau of Animal Industry. Their work showed conclusively that the cause of the disease was a minute parasite living within the blood cells, the intermediate stage of the development of which occurred in the cattle tick, *Margaropus annulatus*, thus making this tick the indirect but absolutely essential factor in the natural production of the disease. Above the latitude where the cattle tick is destroyed by the cold of winter the disease can be controlled by keeping southern tick-infested cattle from passing through the country during certain seasons. It is also known that by severing the relations of the fever tick and native cattle the former may be exterminated, thus making it possible to eradicate the disease, and thereby to remove a constant menace to the southern cattle breeder, feeder, and dairyman. Especial pains will be taken to make as clear as possible the absolutely proved facts regarding the disease, so that every cattle owner will be able to recognize the malady and to carry out successfully measures for eliminating the tick which causes it.

NAME AND SYNONYMS.

Of the long list of terms applied to this disease, none seems to fill completely all the requirements of an ideal name. "Texas fever," although the term most commonly in use in this country, is a very misleading one, as it gives to the uninformed the impression that the disease is confined to the State of Texas. Southern cattle fever is especially inapplicable, as the disease is usually more virulent in northern cattle when once infection becomes manifest than in southern cattle. Probably the best name to apply to the disease, since it can only be transmitted in a natural way by the tick *Margaropus annulatus*, is that of tick fever. This designation, however, is comparatively little used, and, as the disease is generally recognized in this country under the name of Texas fever, this term will be used in the present work. Other synonyms besides those already mentioned are red water, black water, distemper, acclimation fever, murrain, dry murrain, yellow murrain, bloody murrain, Mexican fever, Spanish fever, splenic (or splenetic) fever, protozoan cattle fever, hemaglobinuria, tristeza, paludism of cattle, bovine periodic fever, bovine piroplasmosis, and bovine malaria.

DEFINITION.

Texas fever is a specific infectious disease of the blood of cattle, caused by the development and activity of minute animal parasites (protozoa) which are conveyed to the affected animals by means of the cattle tick *Margaropus annulatus*. After the microscopic protozoan is injected into the blood of a susceptible animal it attacks the red

NOTE.—This bulletin is a revision of and supersedes Farmers' Bulletin 258. It is of interest to farmers throughout the South.

blood cells, causing them to break down. The disease is characterized by high fever, by destruction of red corpuscles, and the consequent excretion of the coloring matter of the blood by the kidneys, causing a reddish discoloration of the urine, by enlarged spleen, engorged liver, thick, flaky bile, more or less jaundice, emaciation, and death in from 10 per cent of the chronic to 90 per cent of the acute cases. The peculiarity about this disease is that the animals responsible for the spread of the malady are apparently healthy, although containing the protozoa in their blood, while those that become diseased do not, as a rule, convey the affection to others. In the few instances where they do, it is not by contact, but indirectly by means of the progeny of the ticks from these diseased animals. Infection is not transmitted by the air, urine, saliva, manure, or in any other natural manner than by cattle ticks.

HISTORY.

Texas fever was probably introduced into the United States with the importations of cattle by the Spaniards during the early colonization of Mexico and southern United States.

The disease caused continual losses year after year during the early history of this country. It seems to have been described first by Dr. J. Pease toward the close of the eighteenth century. At that time a very severe outbreak of the disease occurred in Lancaster County, Pa., and Pease, after investigating the conditions, claimed it to have been due directly to the shipment of some North Carolina cattle into the State. Experience soon showed that the invariable result following the transportation of southern cattle into the Northern States was the death of all northern cattle along the roads and on the pastures over which the southern cattle had traveled, although the latter animals remained perfectly healthy. In the same way northern cattle taken south almost invariably succumbed to the malady.

These losses prompted the study of the disease by many scientific men, whose investigations soon established the great danger of allowing southern cattle to pass into the Northern States during hot weather, and finally resulted in 1885 in the location of the infected district and the establishment of the Texas-fever quarantine line in 1891 by Dr. D. E. Salmon.

Smith, of the Bureau of Animal Industry, was the first (1889) to recognize and describe as protozoa the intracellular parasites which are the direct causative agents of the disease. In 1889 and 1890 Kilborne, of the same bureau, by conclusive field experiments suggested by Salmon, proved the presence of the cattle tick to be essential in the transmission of the disease. It is of interest to note that this was the first experimental proof furnished on the subject of diseases borne by insects, or diseases that can be carried from one animal to another only by an intermediary host. This mode of transmitting infections has since become quite familiar to the public by the discovery that certain species of mosquitoes spread malaria and yellow fever to man.

It was suggested by the experiments of the Bureau of Animal Industry in 1892 and 1893 that, through the production of a mild, nonfatal attack of Texas fever in northern cattle, a very considerable amount of protection is afforded against the disease when these cattle are subsequently exposed to the infection on tick-infested pastures.

From 1895 to 1897 additional experiments were conducted by the bureau with the object of further demonstrating the possibility of immunizing cattle against Texas fever by the use of blood obtained from southern cattle; and experiments with a similar object in view were likewise instigated and perfected about this time at the experiment stations of Missouri, Texas, Mississippi, Louisiana, and by the Australian Government, with most excellent results. Later experiments with the disease have been performed principally with the view of obtaining a satisfactory chemical solution in which to dip tick-infested cattle for the purpose of destroying these parasites, and of developing some methods that may be easily carried out for freeing fields, farms, and counties of the cattle tick.

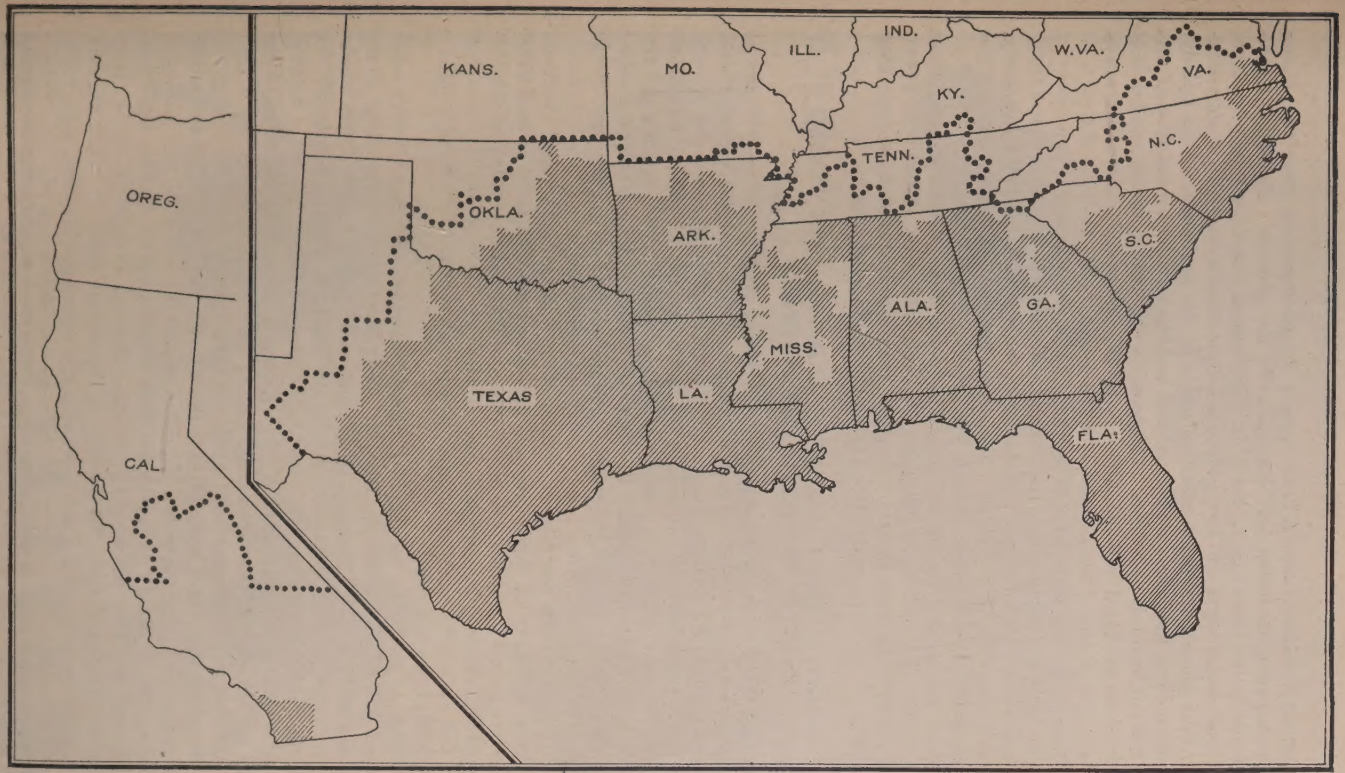

FIG. 1.—Map showing areas quarantined on account of Texas fever and areas freed from ticks; dotted lines show boundary of infected area at beginning of tick eradication in 1906; white areas below dotted line indicate territory that has been freed from ticks and released from quarantine.

CAUSE OF THE DISEASE.

The primary or direct cause of Texas fever is the microparasite *Piroplasma bigeminum*, belonging to the lowest form of animal life, the protozoa. This minute parasite is found in the blood (fig. 2,[1] No. 5) in every case of Texas fever; and by inoculating blood containing it into susceptible cattle, the disease can be invariably transmitted, thus proving its direct causative effect in the production of the malady. After entering into the circulation the protozoa undergo several stages of development which will not be dwelt upon here. The parasites may occupy nearly one-fourth of the body of the red blood cells and, as can be readily understood, exert a detrimental influence upon them. The periphery of these blood cells becomes shriveled or crumpled, and they finally break up, liberating the piroplasma, which may be observed as free bodies in the circulation—most frequently in the kidneys. The stage of reproduction or multiplication of these protozoa has never been observed in this laboratory, but that it does occur is proved by the fact that inoculation of a small quantity of virulent blood into susceptible animals will give rise to the disease with myriads of parasites in the blood. The natural path of entrance of these protozoa, however, is by one channel only, namely, through the bite of the cattle tick. Therefore a knowledge of the habits and life history of the latter is extremely important in controlling the disease, because without this tick Texas fever would be unknown.

LIFE HISTORY OF THE CATTLE TICK AND THE PART PLAYED BY IT IN PRODUCING TEXAS FEVER.

In stating the interesting and important life history of this tick, we will start at the point where the fully developed and fertilized female, being engorged with blood and ready to lay her eggs, loosens her hold on the bovine animal and drops to the ground. Upon reaching the ground she may lie quietly for several days before depositing her eggs, which may consume from four to eight days in summer and two weeks or even longer in the fall. The number of eggs laid by a fully developed female varies from 1,500 to 3,000, while the immature females also lay eggs, but in much smaller numbers. After laying is finished the female is small and shriveled up and, having fulfilled her mission, soon dies (fig. 2, No. 3). The eggs, which are light-brown and waxy in appearance, proceed to develop the larvæ, or seed ticks, the time required for which varies from 13 days to 6 weeks, depending on the conditions of temperature, moisture, soil, etc. These eggs, however, are very tenacious of life, and under unfavorable conditions may remain dormant for several months—from late fall to early spring.

The larvæ, or seed ticks, are minute six-legged parasites of a brownish waxy color, and about $\frac{1}{32}$ of an inch in size (fig. 2, No. 2). They crawl quite actively about on the ground and among leaves, bunching in large numbers upon grass blades, shrubs, weeds, and fence posts, to await an opportunity for attachment to their passing host. The parasitism is so perfect that in case no cattle or horses are present no further development occurs, and death finally results. It is known, however, that these larval forms can live for three or four months on the ground in warm weather independent of their host, and from late September until April during an open winter. When they find cattle, however, they fasten themselves to the soft skin inside the thighs and flanks, on the escutcheon, along the belly and brisket, around the root of the tail, and inside the forelegs (fig. 2, No. 4). They obtain their nourishment by drawing blood from the host, and can cause the fever at this stage, although so small as scarcely to be detected by the naked eye. After being on the animal about one week the seed tick casts its covering (molts) and appears as the eight-legged, nymph stage of the

[1] 1, larva of cattle tick (× 25); 2, same (natural size); 3, mature female and eggs; 4, hide showing cattle ticks; 5, blood cells containing Texas-fever protozoa (× 1,000); 6, male cattle tick (× 15); 7, same (natural size); 8, young female cattle tick (× 15); 9, same (natural size); 10, various stages of cattle ticks.

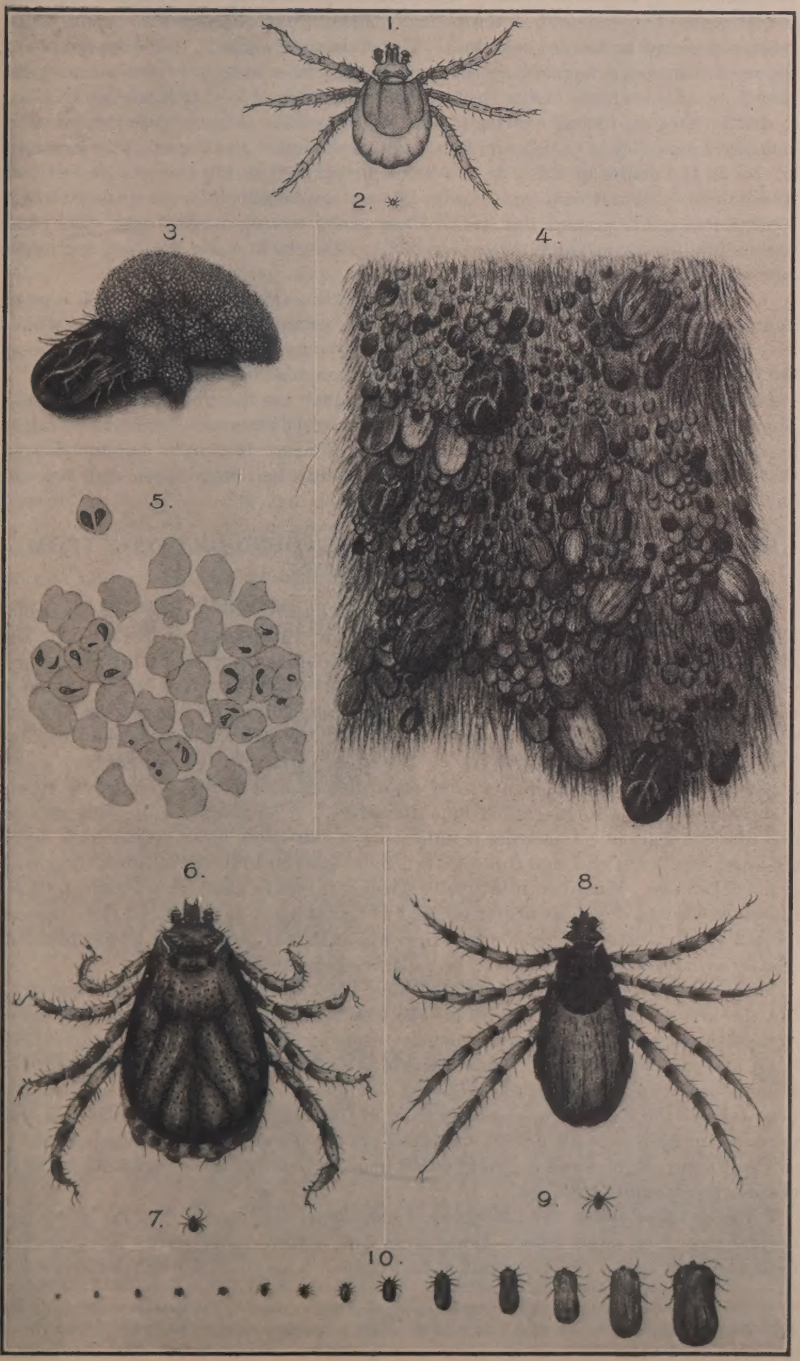

FIG. 2.—Texas-fever protozoa and the ticks which transmit them.

parasite, having added one pair of legs posteriorly. During the nymphal stage the sexual organs develop, and at the second molting, from the nymphal to the adult stage, the sexual organs are complete. The male and female at this stage are about the same size, as the female does not become very large until after she becomes fertilized, which occurs about two weeks after the six-legged seed tick reaches its host, or shortly after the second molting (fig. 2, Nos. 7 and 9). After intercourse with the male the female slowly enlarges for 6 to 20 days in summer, and then rapidly increases in size in the course of a day or two before dropping from the animal. In fall and winter development occurs more slowly, the tick not falling off for six weeks or more. After reaching the ground the female soon commences to deposit eggs, thus completing the life cycle, which requires from 6 to 10 weeks in warm weather, or a much longer period during the cold season.

It will thus be seen that these females transmit the infection through their eggs to their progeny, and the latter have the power to infect any susceptible animal to which they attach. The disease, therefore, is not conveyed by the same ticks which take up the infected blood, but only through the generation descending from them.

Although young ticks are very active, neither they nor the adult ticks are capable of crawling very far, but they may be transported long distances by animals, by rains, by winds, cattle cars, hides, and on the clothing of man. Hence the constant danger that tick-free pastures below the quarantine line may become infested with ticks at any time.

HOW TO DISTINGUISH HARMLESS TICKS FOUND ON CATTLE FROM TEXAS-FEVER TICKS.

The Texas-fever tick is continually confused with a number of other ticks occasionally found on cattle, which, so far as concerns the transmission of Texas fever, are entirely harmless to them. It is this lack of identification and the inability of many cattle owners to distinguish between these various ticks that have caused so many diverse opinions regarding the important part played by the Texas-fever tick in transmitting Texas fever. In order to differentiate between the ticks that may be found on cattle, a brief description of the upper surface of the maturing or adult female of each is here given, together with illustrations of this view of the ticks, natural size, and also magnified four diameters. It is not thought necessary to describe the male and immature female ticks at this time, inasmuch as these ticks are much smaller in size, and therefore it is more difficult to recognize them by means of the naked eye. Moreover, it is usually possible to secure a maturing female in those instances where a diagnosis is desired, and at this stage of development ticks possess certain characteristic features or markings which should cause them to be classified readily as harmful or harmless even by superficial examination.

There are eight species of ticks which have been found on cattle in this country, but the first six mentioned are by far the most common. They all show the same successive stages of development, namely, eggs, larvæ or seed ticks, nymphs, and adult male and female ticks. Those parts of the adult female tick which will be described below are the head and adjacent shield—which together have erroneously been termed the head parts—and the back of the body, since these portions of the parasite furnish features which to the naked eye are the most readily distinguished by cattle owners. Much stress can not be laid upon the color of these various ticks, as it changes considerably with age.

Texas-fever, or cattle, tick (*Margaropus annulatus*).—Figure 3, No. 1a, shows the natural size of an adult female Texas-fever tick, whose characteristic markings are better brought out in No. 1, magnified four times.[1] This tick may be readily distin-

[1] In figures 3 and 4 various ticks that infest cattle are shown as follows: The natural-sized mature female tick, this tick magnified four times, and the head and shield of the same enlarged ten to fifteen times.

guished from the other seven ticks by the small size and the color of the head and shield, the so-called head parts, whose lateral borders are straighter and more parallel, as shown in No. 1b. These head parts are short and relatively broad and dark reddish brown or chestnut brown in color. The body is oblong oval in shape and may reach one-half inch in length. The color varies from a dull yellow to an olive brown; often it is mottled with irregular areas of yellow and brown or streaked with wavy lines of these colors. Two grooves or indentations are seen running from the front to the rear on the skin of the back, which become almost, if not entirely, effaced at about the middle of the body. Another groove is seen between these two grooves in the posterior half of the body. These grooves are caused by the contraction of the muscles of the body and therefore vary considerably, entirely disappearing when the tick is full of blood. They are very distinct when the ticks have been removed from cattle several days. The four pairs of legs are brown, moderately long, and very slender. This tick is found principally on cattle, less frequently on horses, mules, and asses, and in one case it was found on a deer.

Castor-bean tick (*Ixodes ricinus*).—The body of this tick (fig. 3, Nos. 2 and 2a) resembles in shape that of an eggplant, and it takes its name from its similarity to the bean of the castor-oil plant. It is lead colored, with a variegated mixture of yellowish red, brown, or gray. The body contains two anterior grooves that slightly diverge from each other, and three posterior grooves, the middle one of which is straight, while the other two are curved outward. The mature female is from three-eighths to seven-sixteenths inch long and has four pairs of dark-brown thin legs. The head and adjacent shield are a shiny dark brown or a chestnut brown, the latter portion being five-sided, like a pentagon (No. 2b), with lateral borders prominent and rear angle rounded. Two stout and well-developed feelers (palpi) may be seen extending outward on each side of the head. This tick has been collected from sheep, cattle, goats, horses, deer, dogs, cats, foxes, rabbits, birds, man, and a few other animals. It was one of the first ticks studied, and has a very wide distribution in the United States.

Net tick (*Dermacentor reticulatus*).—The body of the adult female tick is oblong oval, five-eighths inch long, and of a deep brown or slate color (fig. 3, Nos. 3 and 3a). It has four pairs of brown legs of moderate length. The skin of the back and head is covered with fine points, or punctations, which almost disappear at this stage. Besides the grooves that are located like those in the cattle tick, there is a marginal groove extending around the body just inside the border. There are also 11 small indentations (festoons) arranged about the posterior margin of the body. These festoons and grooves become shallow or effaced in the adult stage. The shield portion of the head parts has a silvery-white metallic rust extending along the two sides and posterior portion (No. 3b). It may have a rose or greenish tinge. The head is larger than that of the cattle tick. The net tick has been found on man, cattle, horses, sheep, and deer; and in this country it seems to be most common in the West, especially in California, Texas, and New Mexico.

American dog tick; also called wood tick (*Dermacentor electus*).—This tick (fig. 3, Nos. 4 and 4a) resembles the net tick (*Dermacentor reticulatus*) so closely that a hand lens must be used to distinguish between them. However, it can be readily known from the Texas-fever tick by the fact that the so-called head parts are longer and broader (No. 4b). Here there is also a yellowish-white rust in the posterior portion which extends anteriorly along each side as two bright, iridescent lines separated by a central brownish area. The body is oblong oval in shape and measures as much as three-fifths inch in length. The skin of the back contains grooves like those found in cattle ticks, and, in addition, another groove extending around just inside the margin, together with 11 smaller grooves (festoons) on the posterior border. These lines, so distinct in the young female, become shallow at maturity. This tick has been found on man, cattle, dogs, horses, rabbits, and panthers, and has been collected in

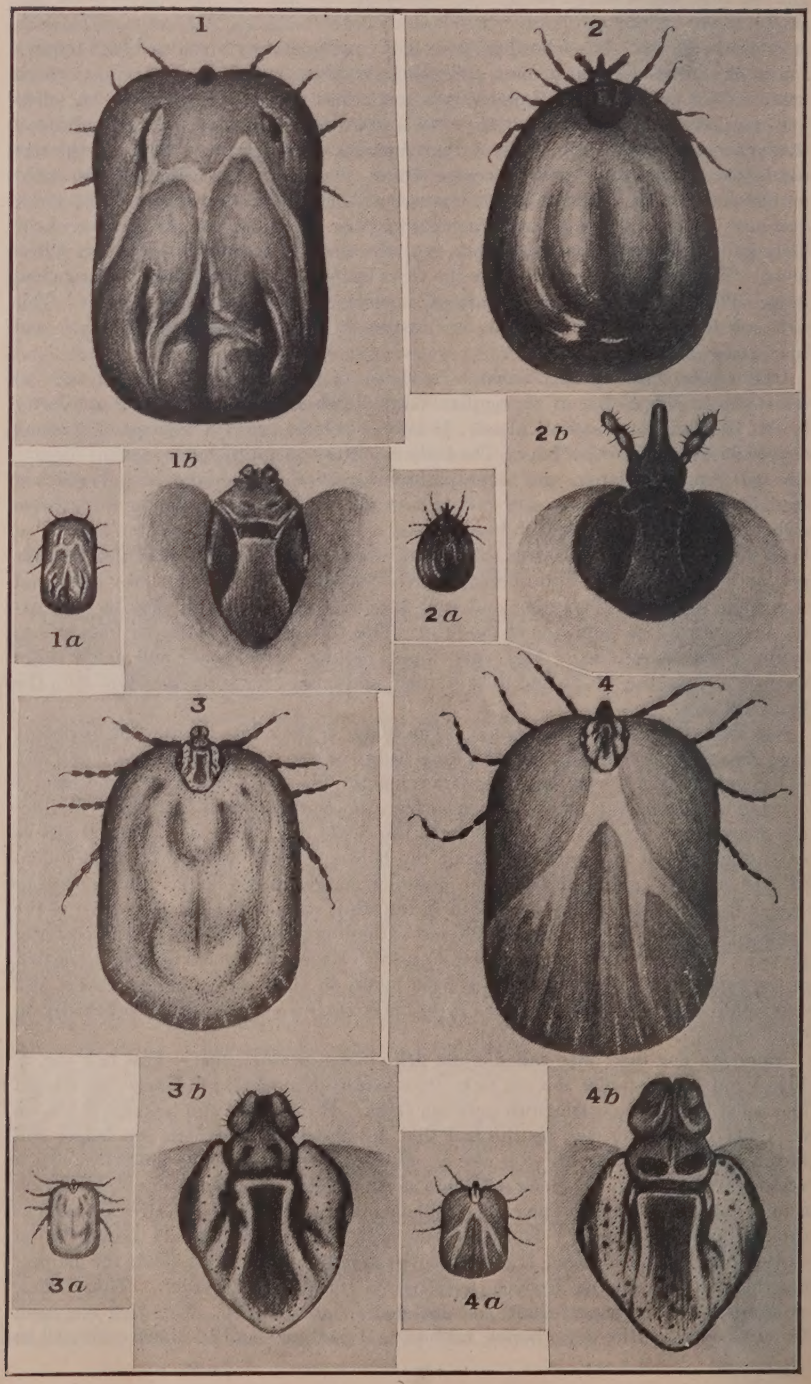

FIG. 3.—Various ticks that infest cattle.

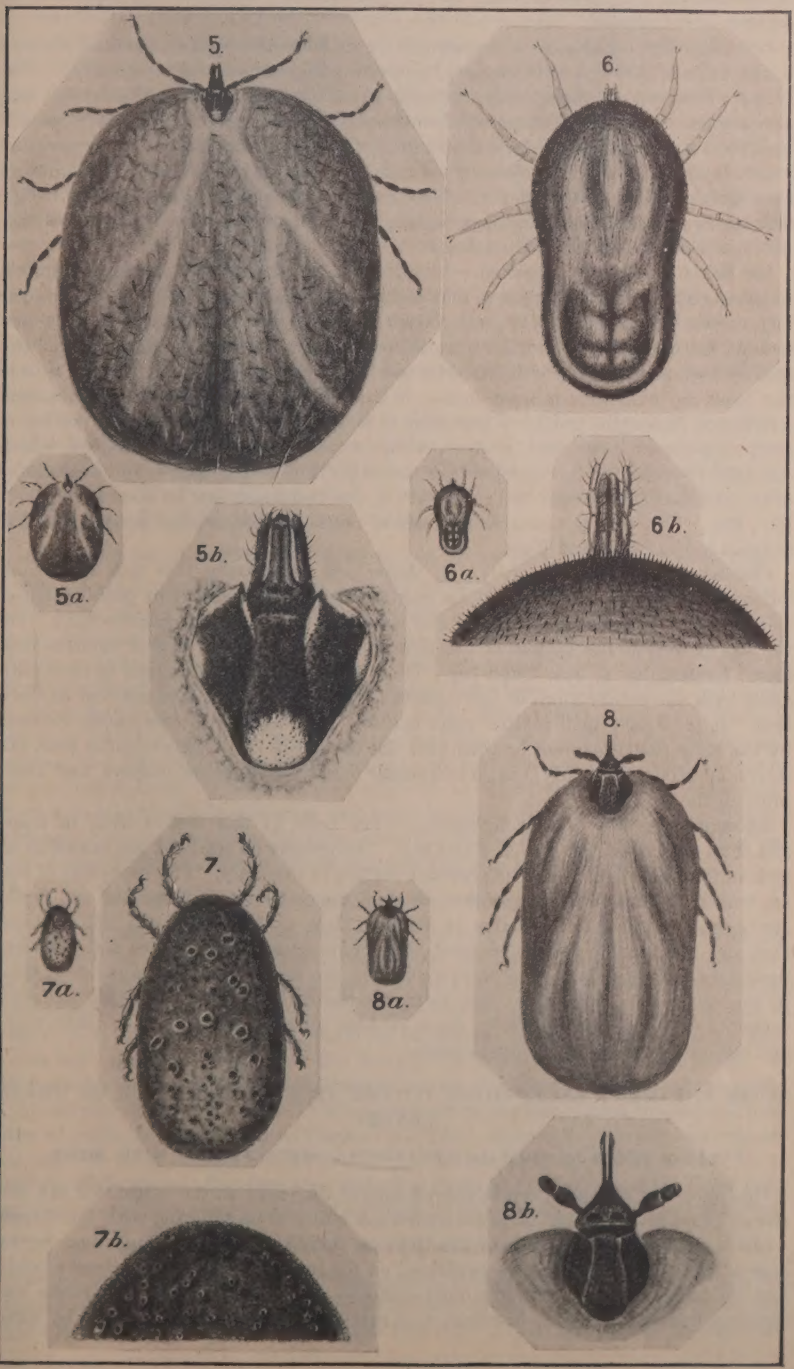

FIG. 4.—Various ticks that infest cattle.

woods and on uncultivated lands in many sections of this country, especially in eastern United States.

Lone Star tick (*Amblyomma americanum*).—As indicated by Nos. 5 and 5a of figure 4, the body of this tick is oblong oval and of a yellowish gray or brown color. The skin is rough and puckered unless the body is full of blood. The reddish-brown area at the front of the tick is composed of the head and head shield. The latter extends backward a short distance to form a triangle, in the apex of which is a white or metallic-yellow spot, from which it derives its name "Lone Star" (No. 5b). The mature female may reach one-half inch in length and has four pairs of long thin legs. This tick has been found on cattle, dogs, horses, sheep, goats, hogs, and man, and is very widely distributed in the United States.

Ear tick (*Ornithodoros megnini*).—As will be observed from Nos. 6 and 6a, figure 4, the shape of this tick is similar to that of the body of a violin. It is nearly twice as long as broad, rounded at both ends, narrower behind than in front, and slightly constricted in the middle. In color it varies from gray or brown to violet, and has two grooves behind the head, with a middle one in the posterior portion. On the skin of the back are numerous minute spines, or stiff hairs. The adult females are from $\frac{1}{4}$ to $\frac{3}{8}$ inch in length, and have four pairs of long stout legs. The anterior portion of the tick is curved downward to form a cover for the very small and short head, which can only be seen from the under side of the tick. The feelers (palpi) and beak, however, stick out from under the front part of the body and can be seen from above (No. 6b). This tick is found in the ears of cattle, horses, mules, asses, and other animals in the South and West.

Chicken tick (*Argas miniatus*).—In shape and appearance this tick is like an enlarged bedbug, and is of a uniform reddish brown color, with four pairs of lighter colored legs. The skin is wrinkled and contains very short and minute hairs. On the top as well as the bottom of the tick are numerous bright pits or cavities with raised borders (fig. 4, Nos. 7 and 7a). These vary in size, are arranged in rows radiating from the center more or less uniformly, and are usually symmetrical on each side. It is about $\frac{3}{8}$ inch in size when mature. The head is so completely covered by the body that it can not be seen from the back (No. 7b). This tick has been observed on cattle once only, but is frequently found on chickens, turkeys, and other birds in the South.

European dog tick (*Ixodes hexagonus*).—The body of this tick is oval in shape and of an ashy color (fig. 4, Nos. 8 and 8a). The grooves on the back are united in an arch in front and diverge in the posterior portion of the body. The four pairs of legs are longer, thicker, and stronger than those of the cattle tick. The head and shield are brown-red in color and similar in shape to those of the castor-bean tick, but less oval and rather more lozenge-shaped, with more acute lateral angles and narrower posterior angle (No. 8a). The palpi, or feelers, are longer and more prominent than in the cattle tick, but not so long as in the castor-bean tick. This tick has been collected from dogs, cattle, sheep, foxes, rabbits, squirrels, gophers, cats, birds, man, and other hosts in eastern United States.

SOME APPARENT EXCEPTIONS TO THE TICK AS A CARRIER OF TEXAS FEVER.

TEXAS FEVER IN ANIMALS APPARENTLY NOT INFESTED WITH TICKS.

One objection that has been advanced against the fact that the cattle tick is a carrier of Texas fever is that cattle are sometimes found to be suffering with the disease without showing the presence of the ticks on their bodies. This condition, in the case of southern cattle, may be explained on the hypothesis that the animal already had its blood infected with the microparasites and under normal conditions was immune from Texas fever; however, as a result of lowered vitality caused by some

other disease, or by exposure, privation, injury, rough handling, etc., this immunity has become reduced and finally overcome, and the parasite of Texas fever, dealing now with an impoverished condition of the animal, succeeds in producing Texas fever. Since the experiments of the Bureau of Animal Industry show that the blood of an immune animal may contain this microparasite for at least 13 years after removal from all sources of infection, it would appear that this recurrence of disease in immune animals placed under adverse conditions could occur at almost any period of their lives, and may be termed a relapse. Thus it has been frequently noted that southern cattle, born and raised in infected pastures but later freed of ticks and placed on noninfected soil, have died of Texas fever when their health was so weakened as to permit the parasites already infecting the blood to overcome the natural resistance of the body and produce the disease.

Again, in certain dipping experiments where the animals had been roughly handled and unduly exposed after having been dipped in a severely irritating solution, a few deaths occurred from Texas fever among cattle which were known previously to have been immune—tick-infested southern animals—but whose vitality had been reduced through these extraordinary conditions.

On the other hand, when this disease is observed in northern animals, the young seed ticks may be so small and so few in number as to be passed readily by even a careful examination, yet numerous enough to cause the affection. In such cases the proof will be found either by prolonged search or in the fact that other animals subsequently take the disease with larger ticks apparent on the skin.

SOUTHERN CATTLE INFESTED WITH FEVER TICKS MAY DIE OF TEXAS FEVER.

When cows born and raised in the South die of Texas fever, it is proof that such cattle never came in contact with infected cattle ticks before, or that they were raised on tick-free pastures, or that they belong to those cases of immune southern cattle which lose their immunity when subjected to adverse or extraordinary conditions, such as those mentioned above. Otherwise they would have been unsusceptible and would not have developed Texas fever. Southern cattle, when raised and kept in districts free from cattle ticks, fail to secure the natural immunity induced by gradual and constant tick infestation from birth, and they are just as susceptible to the disease as are northern animals. Under certain conditions, as when living on horses, mules, etc., fever ticks lose their infectiousness, and when southern cattle not previously infected with any but these noninfected ticks come in contact with infected ticks they are just as susceptible as cattle raised on tick-free pastures, as indicated below.

HARMLESS TICKS MISTAKEN FOR TEXAS-FEVER TICKS.

A very prolific cause for argument against the relation of ticks to Texas fever has been the confusion which exists with reference to the various species of ticks observed on cattle. Some stockmen have claimed that ticks will not cause Texas fever, because their experience has not been with the Texas-fever ticks, but with the species of ticks described in the preceding pages, which are harmless so far as their ability to transmit Texas fever is concerned, or with the noninfected cattle ticks mentioned below. A similar experience with these harmless ticks upon woodland far removed from cattle and confusing them with cattle ticks have led others to claim that it would be impossible to eradicate the latter from infested pastures. However, their life histories are not parallel, since the cattle ticks demand the blood of cattle or equines in order to mature, while the ear, dog, lone star, and other ticks do not. Thus, if the fever ticks can be separated from these animals for a definite period they will die from lack of a host.

SUSCEPTIBLE ANIMALS HAVING FEVER TICKS WITHOUT TEXAS FEVER.

In rare cases it has been observed that certain Texas-fever ticks do not contain the protozoa of Texas fever, and when such ticks fail to produce disease in susceptible animals some persons have been led to argue that none of this species will transmit the

infection. Texas-fever ticks without the virus of Texas fever in their bodies are termed noninfected ticks. They may have lost their infectious property by living on a nonsusceptible animal, such as a horse, mule, ass, or suckling calf, as experiments have shown that a generation of infected ticks on these animals will eliminate the infection from their bodies, and when the next generation of seed ticks is placed on susceptible cattle no disease is produced. These ticks will become reinfected, however, if allowed to infest southern cattle containing the Texas-fever protozoa in their blood. Noninfected fever ticks are so very uncommon that it is necessary to treat all fever ticks as infected and capable of transmitting Texas fever.

FEVER TICKS ON OTHER ANIMALS WITHOUT PRODUCING DISEASE.

The reason that Texas-fever ticks can remain on animals other than cattle without producing the disease is because these animals are not susceptible to Texas fever. Numerous experiments have shown that only bovines contract Texas fever, so it is not difficult to understand why other hosts can be infested with impunity.

OTHER INJURIOUS EFFECTS OF CATTLE TICKS.

Many cattle owners who have always been accustomed to see both ticks and ticky cattle on their farms are unfortunately not inclined to attach much importance to cattle ticks, and, as a rule, through lack of appreciation of their damaging effects, placidly consider them as of little consequence. That ticks may be detrimental to their hosts in several ways has probably not suggested itself to these stockmen, and it therefore seems necessary to emphasize the fact that, in addition to their relation to Texas fever, they may also be injurious to cattle as external parasites. While the power of transmitting Texas fever is undoubtedly the most dangerous property possessed by the cattle tick and is the principal cause for adopting stringent measures in securing its complete eradication, nevertheless there still remain other good reasons for the accomplishment of this achievement. True, a few parasites may remain on cattle indefinitely without causing any noticeable effect, but it is not uncommon to notice bovine animals on pastures with their hides very heavily infested with these pests. In such cases it can readily be seen that the continuous sucking of blood causes more or less impoverishment of the circulation. The cattle must therefore be fed heavier in order to meet the demands of the parasites in addition to the ordinary needs of the animals. This condition, together with the loss of blood, frequently induces an irritable state and evidences of uneasiness commonly known as "tick worry," which results in the loss of energy and in other derangements of the animal's health. It may in some cases become so pronounced, especially in hot weather, that the animal will lose flesh in spite of good pasturing, thereby reducing the vitality and rendering it more susceptible to the inroads of disease. Moreover, if the infestation of ticks is not controlled, the cattle may be so reduced in condition that growth is retarded, and, in the case of young animals, they may never become fully developed, but remain thin, weak, and stunted—a condition that has been termed "tick poverty"—and easily succumb to other diseases as a result of lowered vitality.

In milch cows this debilitating influence of the numerous ticks is shown in a greatly reduced milk supply. This should not appear strange when it is considered that some animals harbor many thousands of these bloodsucking parasites. If these parasites are crushed it will be found that their intestines are completely filled with a dark, thick mass of blood abstracted from the animal host and containing nutriment that should go to the formation of milk and flesh and the laying on of fat. In some rare cases the large number of bites over a limited area of skin may be followed by infection with pus-producing organisms, giving rise to small abscesses which may terminate in ulcers. The discharge from such sores, or in some cases the mere oozing of blood serum through the incision made by the mouth parts of the ticks, keeps the hair moist

and matted together, and the laying and hatching of fly eggs in these areas give rise to infestation with destructive maggots, causing ulcers and other complications that require medical treatment.

These statements regarding the secondary injurious effects of cattle ticks also apply to those ticks which have been previously spoken of as harmless in so far as Texas fever is concerned, and, in fact, to all external parasites. Therefore, it is just as important to eradicate the cattle ticks for reasons other than those associated with Texas fever as it is to exterminate lice, fleas, and other vermin. Furthermore, cattle ticks, aside from the losses sustained by their purely parasitic effects, are the greatest menace to the profitable raising and feeding of cattle in the South, because they are an obstacle to cattle traffic between the infected and noninfected districts.

LOSS OCCASIONED BY CATTLE TICKS.

The economic aspect of the tick problem is unquestionably of the greatest practical interest, since the fundamental importance of all the other questions which surround it depends upon the actual money value involved. It would therefore seem advisable to furnish a few statistics showing the financial loss sustained by the country as a result of the presence of this parasite. It is well known that those animals coming from an infected district and sold in the "southern pens" of northern stockyards bring an average of one-fourth to one-half a cent less per pound than the quoted market price. The handicap that is placed on the southern cattle raiser as a result of this decrease in value of his stock will average at the former figure at least $1.50 per head, allowing an individual weight of 600 pounds for all classes of animals, so that the loss on the estimated 705,000 southern cattle, including stock, beef, and dairy animals marketed yearly under these conditions, will sum up a loss of $1,057,500 per annum. Carrying this estimate still further, it will be found that this decreased value reacts and fixes the valuation of all cattle which remain in the infected territory, thereby reducing the assets of the cattle industry of that section by this ratio per head for the four and a half millions of cattle east of the Mississippi River and the eleven millions of cattle west of the Mississippi River, or, all together, the enormous shrinkage in value of $23,250,000 directly chargeable to the cattle tick. This sum, however, should not be considered in determining the yearly devastation caused by the cattle tick, but rather as an unnecessary reduction in the assets of the infected country. This last loss does not include the decrease in flesh and lack of development of southern cattle occasioned by the parasitic life of the ticks from without and by the blood-destroying and enervating properties of the protozoan parasites from within, an additional loss which is so very great that a conservative estimate would place it equal to the loss mentioned, or $23,250,000.

The presence of the tick among the cattle of the South not only lessens the value of the cattle on the hoof but causes the gradings of hides that have been infested with ticks as No. 4 quality. The same hide, if free from tick marks, would grade No. 2. The difference in price between these two grades of hides is 3 cents a pound. As the hide of southern steers weighs about 42 pounds, the presence of the tick in the hide causes a loss in the hide alone of more than $1.26 a hide. It has been shown that the cost of tick eradication is only about 50 cents a head, so that if the counties make a systematic campaign to eradicate the tick, the increase in value of the hide alone would pay for the cost of tick eradication and leave the farmer a net profit of about 76 cents a hide.

The shrinkage in the milk production of cattle harboring many ticks will average about 1 quart per day, and the loss occasioned thereby at 3 cents per quart for the 875,000 ticky dairy cattle out of more than 4,000,000 dairy cattle below the quarantine line would amount to $26,250 per day, or, counting 300 milking days for each cow to the year, $7,875,000 per annum. The damage resulting to the southern pur-

chaser of northern purebred or high-grade cattle is another item of no small moment. About 10 per cent of all such cattle taken South die of Texas fever even after they are immunized by blood inoculations, and about 60 per cent of these cattle succumb to Texas fever when not so treated. Since they are usually very expensive animals and of a highly valued strain of blood, the loss in certain cases is excessive and in others almost irreparable, owing to the possible extinction of some particular type especially selected for the improvement of the herd.

Another instance where it is difficult to figure the injury done by the ticks is in the case of death of nonimmune cattle in the tick-free pastures of the South. Such animals are as susceptible to Texas fever as nonimmune northern cattle, and, inasmuch as there are in many sections only one out of every four farms infested with ticks, the cattle on the remaining farms will in many cases contract Texas fever when exposed to the fever tick. These losses can scarcely be computed, as the death rate depends so much on the season of the year when exposure occurs and on the age of the animal affected. However, the deaths among such cattle are considerable, although this fact is little appreciated or understood by many outside of the infected area. The loss thus occasioned has been estimated at $5,812,500 per annum. And this sum, excessive as it may seem, represents a smaller percentage of loss on the total valuation of neat cattle than has been determined by several of the infected States.

On rare occasions a small outbreak of Texas fever occurs north of the quarantine line as a result of improperly disinfected cars, of unscrupulous dealers breaking the quarantine regulations, or of some accidental condition. Such damage, however, is slight, but should be given consideration in summing up the loss occasioned by the fever tick.

The advertisement which a breeder obtains and the sales which are made by having his stock in the show ring are usually lost to the southern cattle raiser who aspires to display his animals in the North, as they are barred from most of these exhibitions. On the other hand, the southern farmer is not given an opportunity to see and be stimulated by the fine specimens of northern cattle which might be shown at southern stock exhibits for the reason that the danger of contracting Texas fever is too patent to warrant such exposure. The expense incurred by the Government and the various States in enforcing the regulations that apply to the quarantine line reaches about $65,000 per annum.

Another loss which is indirectly sustained by the southern cattle industry through increased freight rates is the cost to the railroad companies of cleaning and disinfecting the cars that carry southern cattle and in providing separate pens for these animals at various locations. This sum may be calculated at not less than $29,000 per annum.

If all the above-mentioned losses are added, it will be found that the Texas-fever tick is responsible for about $40,000,000 of loss annually to the people of the infected country, and that it also lowers the assets of the South by an additional $23,250,000. These figures are not given as accurate in any particular, but they are sufficiently close to indicate that the loss to the quarantined section from the cattle tick is something enormous. Such a series of incumbrances as those recorded could be carried by the cattle industry of no other section of the country but the South, whose excellent pastures, rich soil, and salubrious climate are the only reasons for its ability to overcome such obstacles in meeting the competition of the West. And it is the inherent capacity of the South for greatly increasing its herds and enlarging its pasture lands that makes the actual loss even secondary to the potential loss due to restrictions necessitated by the presence of the cattle tick. This potential loss may be described as the difference between the value of the cattle industry of the South to-day and the extent to which this industry would be increased if farmers and ranchmen were assured that their lands and cattle would not become infested with fever ticks. Could this assurance be given, the beneficial effects would extend over the

entire country, because the market of the northern breeder would thereby become greatly extended.

These appalling losses and annual sacrifices of the cattle raisers of the infected district can be entirely effaced, and this at a small proportionate cost; for, with enthusiastic stockmen, satisfactory State legislation, sufficient money, and a trained corps of inspectors, the cattle tick may be exterminated, and every dollar expended in this work will be returned manyfold during each succeeding year.

PERIOD OF DEVELOPMENT OF DISEASE AFTER EXPOSURE TO TICKS.

The length of time elapsing between the exposure of susceptible cattle to the cattle tick and the appearance of Texas fever among them is dependent upon the climate and the development of the ticks. Thus, if any northern animals are placed upon pastures, highways, or in pens, cars, etc., in summer immediately after the premises have been infested with ticks from southern cattle, Texas fever may occur in from 30 to 60 days, as the females that drop from the southern cattle must lay eggs and these must hatch before the northern animal becomes infested with ticks, and thereby inoculated with the disease. In cool weather this period may extend to 90 days, as it takes much longer for the eggs to hatch. Where northern animals are not exposed in an infested pasture until the ticks which fell from the southern cattle have laid eggs and the larvæ, or seed ticks, are already present, the northern cattle will develop symptoms in 13 to 15 days in hot weather. Thus under natural conditions the disease appears in 13 to 90 days after exposure. After the seed ticks become attached to the animal the disease will appear in about 10 days in summer, and after a somewhat longer period in cooler weather. In fact, the disease may occur before the ticks are large enough to be seen without a very careful search. By artificially inoculating a cow under the skin or into a vein with virulent blood the disease may be produced in 3 to 10 days.

SYMPTOMS.

The symptoms of Texas fever present two distinct types, the acute and the chronic, depending upon the time of year the disease makes its appearance and the susceptibility of the animals attacked.

ACUTE TYPE.

In the acute form of the disease the temperature rises within 24 to 48 hours to 107° or 108° F., and the animal rapidly shows signs of being affected with a severe malady. It is depressed, leaves the herd, and lies down or stands off by itself with head lowered, ears dropped, feet drawn together, and back arched from the pain in the liver and kidneys. The muzzle is dry, the appetite lost, and rumination ceases. Constipation is always present during the first stages of the disease, but it frequently gives place later to diarrhea, and the manure is usually heavily stained with bile and in rare cases may be mixed with blood. The number of respirations may rise to from 50 to 90, while the pulse beat varies from 90 to 120 per minute.

The changes which occur in both the urine and blood are extremely important, but the urine will receive first consideration here, as it is more readily examined by the layman than the blood. The peculiarty of the urinary secretion is that it is blood-stained, from which symptom the disease has derived its name of "red water." The protozoa in the circulation break up the red corpuscles, liberating the hemoglobin, which is the coloring matter of the blood. This discoloration of the urine is present in the majority of the acute cases, but it is frequently wanting in the chronic form of the disease. The color varies from a mere pinkish tint to an almost black color, depending on the rapidity of destruction of the red cells and the excretion of the coloring matter through the kidneys into the urine.

The blood also furnishes great assistance in making a diagnosis of suspected Texas fever, and the finding of the intracellular parasite microscopically is conclusive evidence. The blood, as it oozes from a small incision in the skin, is pale and watery, indicative of great reduction in the cellular element, and is readily seen to differ markedly from the normal red blood of healthy animals. Sometimes there is such a lack of blood in the vessels of the skin that a very deep incision has to be made in order to obtain sufficient blood for inspection. It is also at times noted that the power of the blood to coagulate is so reduced that when it once starts to flow it is only after a considerable time—or by applying pressure—that the hemorrhage is stopped. In the majority of cases, however, the tendency of the blood to clot is unaffected.

Cerebral symptoms are noticed in a certain percentage of cases, manifesting themselves in the form of staggering gait, disturbances of vision, or delirium. There is in milch cows a reduction or a complete stopping of the milk secretion. Abortion is also very common in pregnant animals. Death usually occurs within three or four days, and is generally preceded by a marked fall of body temperature to normal or even subnormal a few hours before the fatal termination. In nonfatal cases the temperature falls gradually after the crisis and soon reaches the normal, but recovery is prolonged over weeks and even months, as a great deal of time is required to regenerate the greatly impoverished blood.

CHRONIC TYPE.

The chronic form of the disease appears under natural conditions usually in the late autumn and early winter. It can be produced experimentally, however, by placing a few ticks on the skin of a susceptible animal—a fact of very great importance in the production of immunity against the acute type among northern cattle.

This form shows all the symptoms of the acute type, but in a milder degree. The temperature usually remains about 103° and never exceeds 105° F. There is loss of appetite, stoppage of rumination, constipation, and albumen in the urine. An anemic condition of the blood, as indicated by the pale and bloodless mucous membranes, is also present, but hemoglobin is not usually excreted by the urine, hence the red-water symptom is absent. There is also excessive loss of flesh and, before the end of the attack, the affected animal is greatly emaciated. Although death rarely occurs, the valuation of the animal is much reduced.

RELAPSES.

Following recovery from an acute attack, when the red blood cells have apparently reached their normal number, there has frequently been observed a relapse or recurrence of the disease in the mild, chronic form, accompanying which there is a second period of destruction of the red cells. This follows within three to six weeks after the symptoms of the acute attack have subsided. For a considerable time it was unknown whether this was a relapse of the acute attack or due to reinfection from a second generation of ticks. Smith and Kilborne, however, proved that it could occur as a relapse without the presence of ticks, but it may also in some cases be caused by a second extraneous infection.

APPEARANCE AFTER DEATH.

The post-mortem examination should be made as soon as possible after death, as the carcass of an animal dead of Texas fever undergoes decomposition very rapidly. The skin should always be first examined for the presence of the cattle tick, as the discovery of any of the forms of this parasite on the skin of the escutcheon, thigh, or belly leads at once to a suspicion of the presence of the disease. The skin is usually normal in appearance, no visible alterations being present except possibly the small swellings, minute hemorrhages, and perforations from the bites of the ticks. Upon cutting into the hide and skinning the carcass, a marked lack of blood in the blood vessels of the

skin and underlying tissues is observed. Occasionally there may be noted a yellowish jaundiced discoloration of these tissues. This is due to the alteration of the bile-secreting function of the liver, but is by no means present in all cases, being most constant in the acute, rapidly fatal form of the disease.

Probably the most marked pathologic alterations in the disease are found in the liver. This organ is very much enlarged and has a yellowish, mahogany-brown color, due to the bile it contains. This secretion becomes excessive, and minute plugs of congealed bile form in the small bile ducts, thus stopping them and damming the bile in the organ, which produces the yellowish color. This does not occur evenly throughout the organ, and consequently it has a mottled appearance. The gall bladder is usually distended with bile, and its mucous membrane often contains numerous minute hemorrhages or blood-shot spots. The bile is very thick, has the appearance of "chewed grass," and contains numerous firm, irregular flakes. The spleen also shows marked changes. Normally this organ weighs from 1½ to 2½ pounds, but in cases of Texas fever it is enormously enlarged, sometimes reaching four times its normal dimensions. It is very dark at times, due to the enormous accumulation of red cells and hemoglobin within its substance. Upon cutting into it the pulpy tissue will sometimes run out as a semifluid blackish mass, due to the breaking down of its structures.

In death from the acute type of the disease the kidneys are usually found to be very dark in color and congested. The blood vessels are engorged with blood, and there is watery infiltration of the surrounding fatty tissue. In the older, more chronic cases the kidneys are paler and somewhat flabby.

The bladder usually contains a varying quantity of urine, which may or may not be blood stained. The mucous membrane frequently contains a few minute hemorrhages.

No characteristic lesions are found in the stomach, intestines, heart, or the lungs.

COURSE AND TERMINATION OF THE DISEASE.

The course of the disease depends not only upon the time of the year the infection occurs, but also on the age, strength, and susceptibility of the animals attacked. When mature susceptible cattle contract the disease in the hot summer months, death usually occurs within a week—generally three or four days—after the first appearance of symptoms, but it may follow inside of 24 hours.

In the infections of partially immune southern cattle and when nonimmune cattle are infected in the late fall, however, the course of the disease is much more prolonged and covers a period of many weeks or even several months. In this type the continuous fever causes exhaustion, while at the same time the enormous destruction of red blood cells interferes very materially with the nutrition of the patient. As a natural consequence, emaciation becomes marked, and this, together with the poor appetite, leads to a fatal result in some cases. In the majority of cases, however, in spite of the severe alterations of the blood and internal organs, the animals begin after several weeks to show improvement. The temperature becomes normal and there is a tendency toward regeneration. This, however, requires weeks and months, the animals in the meantime appearing weak and thin, having pale mucous membranes. During the recuperative period the animal should by no means be fed excessively, as numerous cases of fatal gastrointestinal disturbances have been reported from overfeeding. The few animals which recover from the acute type of summer are quite likely to have a relapse in the form of the chronic type in the fall.

The mortality in adult susceptible cattle, as the above statements readily show, may vary considerably, and ranges from 90 per cent in the months of July and August to less than 50 per cent in the late autumn and early winter. The prognosis must there-

fore depend on the time of year the outbreak occurs. In animals under 9 months of age the course of the disease is usually short and the affection seldom fatal, while the death rate among 1-year-old cattle during the hot season is about 25 per cent and less than 10 per cent in the fall and winter. Between 1½ and 2 years of age the mortality is about double that at 1 year.

INFECTIVE CHARACTER.

Texas fever belongs to the group of infectious diseases, and it is a typical example of the few diseases of this class which do not combine the property of being contagious. It is infectious because it is due to the entrance and multiplication of a pathogenic microorganism within the body, but sick animals, in the absence of ticks, can remain in intimate association with healthy susceptible animals indefinitely without transmitting the disease to them, and hence it is not contagious. Furthermore, a cow perfectly healthy in appearance may contain in its blood the Texas-fever protozoan, which, when transmitted to susceptible cattle by the fever tick, will produce the disease. It is certain that the piroplasma are present in varying numbers in the manure and urine of infected animals, and yet susceptible animals have never been known to become affected from grazing over tick-free pastures soiled with excrement from sick animals.

The experiment was made by the Bureau of Animal Industry of polluting a pasture with the blood and spleen of an animal dead of Texas fever and then allowing susceptible cattle to graze in the field for two months, but the animals remained perfectly healthy. Moreover, the feeding of ground-up ticks and virulent blood failed to produce the disease, showing that the digestive tract is proof against the infection.

The disease therefore can be transmitted by three known methods only: (1) By the bite of the cattle tick; (2) by inoculating the blood of sick animals into healthy animals; (3) by inoculating the infected blood of apparently healthy southern cattle into nonimmune cattle.

ANIMALS AFFECTED.

Numerous experiments have been made on various species of animals with highly virulent blood from cattle suffering with Texas fever, but the disease has been produced in bovines only. Among those animals that have failed to develop the disease after inoculation may be mentioned horses, asses, sheep, pigs, dogs, cats, mice, rats, guinea pigs, rabbits, chickens, and pigeons. All bovine animals that have never been exposed to the disease are susceptible to Texas fever, although sucking calves are so resistant as to be practically immune. Adult cattle are the most susceptible, and, if attacked in the summer months, usually die, while in the fall and winter they more frequently recover. Calves under 8 months of age contract the affection in a very mild form, as a result of which they become immune from the disease.

DISEASES MISTAKEN FOR TEXAS FEVER.

The two diseases of cattle which may be confounded with Texas fever are anthrax and blackleg. The following are the main features of Texas fever not found in anthrax: Young ticks are usually found on the hide of the affected animal; if occurring in the uninfected territory, the disease can invariably be traced to the shipment of southern cattle into the locality 30 to 90 days previously; young sucking calves as a rule are not affected; the mucous membranes become extremely pale and jaundiced, while in anthrax they are very red and congested; cattle only are attacked, while anthrax attacks all animals. Upon post-mortem examination in Texas fever the tissues under the skin are very pale, while in anthrax they are congested, with the blood vessels standing out prominently. The blood is thin, pale, and watery, whereas in anthrax it is tarry, black, and incoagulable. The bile is semisolid and

contains numerous hard flakes, while in anthrax it is fluid. The spleen is affected quite similarly in both diseases, but the liver in Texas fever is enlarged, yellowish, and mottled from the plugging of the bile ducts, whereas in anthrax the liver, although enlarged, is very dark in color and is congested.

Texas fever can usually be differentiated from blackleg by the fact that the great majority of victims of blackleg are between 6 months and 2 years of age. There is usually a total absence of ticks on the hide in the latter disease, while there are present superficial crackling swellings which on being opened are found to contain gas bubbles with the peculiar odor characteristic of the disease. There is also an absence of blood-stained urine. On post-mortem examination in blackleg the muscular tissues beneath the swollen areas are very dark and soft, with bloody fluid, while the liver, spleen, and kidneys are apparently unaffected.

PREVENTION.

It is generally accepted that if southern cattle are entirely free from that species of tick known as *Margaropus annulatus* they can be allowed to mingle with the most susceptible animals without danger. Furthermore, it has been learned from the study of the life history of the cattle tick and from the fact that this tick infests pastures only transiently, never permanently, and will not mature except upon cattle or equines, that its extermination is possible, and that the disease it causes may be prevented. Therefore, the various methods with these results in view should be directed toward the destruction of ticks on cattle as well as their eradication from the pastures.

The details of these methods of eradication will not be discussed here, as this subject is fully treated in Farmers' Bulletin 498, "Methods of exterminating the Texas-fever tick," which may be obtained free upon application to the Department of Agriculture, Washington, D. C.

IMMUNIZATION OF SUSCEPTIBLE CATTLE.

BY BLOOD INOCULATION.

It is often desirable to ship well-bred cattle into infested districts that they may be used to improve the quality of the native cattle already there. Previous to the discovery of the cause of Texas fever it was found to be well-nigh impossible to introduce purebred cattle from the north into any of the infected regions without suffering great loss—sometimes as high as 90 per cent—within a few months of their arrival at their southern destination. It has now been found practicable to immunize this class of cattle so perfectly that the losses which follow their transportation to a tick-infested region are reduced to a minimum. Young animals 6 to 15 months old should, so far as possible, be selected for this purpose, as they are more readily immunized than adults, are more easily handled, and the dangers which may arise from pregnancy while undergoing the immunizing treatment are thus avoided.

Immunity in these cattle is obtained by introducing the microparasite of the blood into their systems. It may be done by direct artificial inoculation or by placing virulent young ticks upon the animals and allowing them to perform the inoculation in the natural manner. The subcutaneous injection of a small amount of defibrinated virulent blood has been found, by means of prolonged experiment, the preferable method, as the number of microorganisms introduced can be more accurately gauged from the syringe than by allowing the infection to be produced by bites of ticks. Two or three inoculations, if repeated at proper intervals, are accomplished with greater safety to the animal than would be possible by means of a single inoculation. The amount first injected should be small and then gradually increased in the succeeding treatments.

The inoculation always results in a more or less serious attack of Texas fever. Besides having a fever, there is a great diminution of red blood cells, and in about 3 per cent of the cases a fatal termination; but the proportion of deaths resulting from the inoculation is small when compared with the fatalities among untreated animals taken into infested districts. To this number should be added those animals (less than 7 per cent) that do not receive sufficient immunity by this method and which succumb when exposed to infested pastures. Combining these failures it will be seen that by this method of immunization, instead of a loss of 90 per cent among breeding stock taken South more than 90 per cent can be saved. The animals should be carefully nursed through the attack and treated symptomatically.

Immunizing inoculations are now being made by the veterinarians of some of the agricultural experiment stations of the Southern States without cost for the services rendered, a charge being made merely for the actual value of food consumed by the animals and attendants' wages. These veterinarians have also issued station bulletins which describe fully the necessary steps to be taken in securing the blood and injecting it into the animals to be immunized, so that the stock owner can follow the instructions with prospects of getting good results.

This operation is not a difficult one, and excellent results will follow where absolute cleanliness and ordinary care have been used, but undoubtedly the best results will be obtained by those who have thoroughly familiarized themselves with the nature of the disease and are experienced in extracting blood from animals. Two methods are in use and will be described separately. One consists in drawing the blood from the jugular vein of an immune animal and immediately injecting it into the cattle to be immunized. It is comparatively simple, requires few instruments, and can be satisfactorily carried out where a small number of animals are to be immunized and if a suitable immune animal is close at hand. First, select an immune animal which is in good health and which is infested with fever ticks or had them the preceding year. Fasten the animal securely, either by tying, throwing, or by placing in a chute. Clip the hair from a space about 4 inches in diameter over the jugular vein on the upper third of the neck, wash the skin thoroughly with a 5 per cent solution of carbolic acid, and then fasten a strap or rope around the neck below the hairless area and draw it tight in order that the blood in the vein will be stopped, causing distension. With a large hypodermic syringe needle, previously sterilized in a 5 per cent carbolic-acid solution, puncture the vein at a slight angle, directing the point forward. When the needle enters the vein the point can be rotated freely in contrast to the restricted movements if still in the tissues, and the blood will either drop or flow from the opening in the needle. Attach the disinfected syringe to the needle with piston in and gradually draw out the piston until the chamber of the syringe is full of blood, when the needle is withdrawn. From a yearling in fair condition a pint of blood may be taken without harm, while double this quantity may be taken from a 2-year-old, and four or five times as much from a 3-year-old or upward. The blood, before it has had time to clot, is immediately injected into the animals to be immunized and which have been previously tied or restrained, the hair clipped, and the skin disinfected at the seat of injection in the region of the shoulder. Inject then from 1 to 3 c. c., according to the age of the animal, under the skin of each animal until the blood is exhausted. When more animals are to be inoculated than one syringeful will inject, the operation may be repeated in the same manner. The only objection to this method is the possibility of the blood clotting in the syringe, but with practice and promptness this can be easily overcome.

The second method is better suited for the inoculation of a large number of cattle or where the immune animal is at a distance from the cattle to be immunized.

The preliminary steps—the clipping of the hair, disinfection of the skin, placing the rope around the neck to distend the jugular vein, and restraining the animal—are the same as for the first method. In puncturing the vein it is advisable to use a small

trocar and cannula after sterilization in a 5 per cent carbolic-acid solution, and, when the vein has been entered, to draw out the trocar, allowing the blood to flow through the cannula attached to a rubber tube into a perfectly clean and sterile vessel containing a 5 per cent solution of citrate of potassium or sodium, to prevent the coagulation of the blood. The amount of citrate solution in the container should be one-twentieth of the quantity of blood which it is desired to collect. After sufficient blood has been drawn for the animals to be injected, a cork is placed in the top of the bottle through which passes a long rubber tubing. At the other end of this tubing is a needle and in the middle is a T joint with a syringe at the stem of the T. By the use of valves at this joint the withdrawal of the syringe piston pulls the blood from the bottle, and the insertion of the piston with closure of the opposite valve ejects the blood from the needle. The citrated blood is inoculated under the disinfected skin of the animals to be immunized, as in the first method. This blood may be kept in a dark cool place for one or more months without deteriorating and may be shipped to other points for use.

The place where this injection is made is immaterial, but for convenience a point just behind the shoulder is usually chosen. The dose and number of injections vary

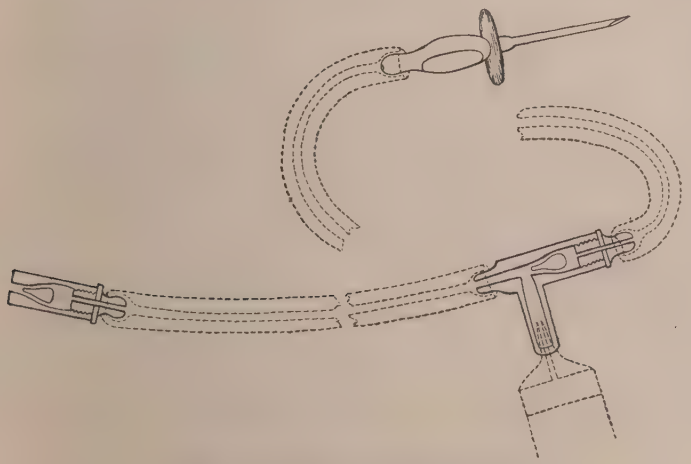

FIG. 5.—Syringe for injecting blood.

with the individual animals. When a large number of cattle are to be inoculated a special form of syringe devised by Pound, of Queensland, may be used. (See fig. 5.) The syringe is so arranged by means of tubes and valves, that by simply pulling out the piston of the syringe and pushing it in again the correct amount of blood is drawn up from the bottle and injected through the needle into the animal, thus obviating the necessity of continually filling the syringe and measuring out the dose. As a rule, it may be stated that 1 cubic centimeter should be injected into an old animal coming into the infested district, 2 cubic centimeters for a 2-year-old, and 3 cubic centimeters for an animal 9 to 15 months old. It will be observed that, unlike the usual custom of applying treatment, the older animals take less than the young ones, owing to their greater susceptibility to the disease. Where an animal has reacted well to a first injection and shows a very high temperature, great reduction of red blood cells, or other symptoms indicative of reaction, it will not be necessary to repeat the injection, but in those cases where the reaction is slight, a second injection should follow after an interval of 40 days, and, if need be, a third injection after a similar lapse of time, always increasing the size of dose 50 per cent. A thermometer, to indicate the course

and severity of the disease, is indispensable in this work. Usually after 3 to 10 days, sometimes longer, the inoculated animals show a mild type of Texas fever, which runs a course of from 6 to 8 days and is followed in about 30 days after the injection with a second attack of a milder character than the first. After 40 days, when the animal has entirely recovered from the inoculation, a second injection may be given to increase its immunity. In some cases a very severe type of fever follows the first inoculation, requiring careful nursing and symptomatic treatment. A second, milder attack follows usually in about 30 to 40 days, after which the animal need have no further inoculations. It is advisable to prevent any ticks from getting on the cattle until 60 days after their inoculation or until they have fully recovered, at which time a few ticks may be placed upon them in order to reenforce their immunity. Naturally this time varies according to the type of the attack. As the best results with these immunizing experiments have been obtained in cool weather and with young cattle, it is recommended that animals from 6 to 15 months old be selected for inoculation, and that they be immunized during the late fall or winter months, in order that they may enter tick-infested pastures in the spring without danger.

BY INFESTING WITH TICKS.

Immunity may also be induced in susceptible animals by placing a limited number of fever ticks upon their bodies in order to produce the disease naturally. For this purpose only animals less than 1 year of age should be used, as the method is not applicable for older and more susceptible animals. Upon the bodies of these young cattle from 25 to 50 seed ticks should be placed, which in the course of about 10 days will occasion a rise of temperature and a mild form of Texas fever. When the animal has entirely recovered from this attack, a second crop—double the number first used—should be applied to the animal in order to increase its power of resistance when pastured on infested soil. In order to carry out this method successfully a constant supply of seed ticks must be at hand. This can be accomplished by placing the mature females in a Mason fruit jar among some dirt and leaves and keeping them in a warm place. In a few weeks the eggs will have been laid and hatched, and a number of seed ticks will be present for use in infesting the cattle to be immunized. By placing a few adult females in the jar every two months there will always be a supply of these young ticks. This method of producing immunity by controlled tick infestation is not so safe as blood inoculation, since the quantity of germs injected can be more accurately regulated by means of a syringe.

FEDERAL SANITARY REGULATIONS.

The sanitary regulations which have been enacted by the Department of Agriculture for the control of cattle shipments from the infected districts have for their initial purpose the prevention of the transportation of cattle ticks from infected regions to those that are not infected, either upon cattle or in stock cars or other conveyers, during the season of the year when infection is possible. They are based upon the fact that Texas fever is carried north only by the cattle tick; and the exclusion of this parasite from the noninfected territory has in every instance been found a certain method of excluding Texas fever.

The regulations governing the movement of cattle from below the quarantine line are made yearly by the Secretary of Agriculture and they define the boundary of infected districts. In consequence of the enforcement of these quarantine regulations Texas fever has been practically prevented in the noninfected districts during the last several years, and little or no hardship has been caused to those stockmen handling cattle from the infected areas. Previous to their adoption the tick-infested district was rapidly extending northward, but since the quarantine line was established and rational regulations enforced it has gradually been moved farther south.

This problem of still further reducing the infected area is of the greatest importance to the cattlemen of the South—in fact, to those on both sides of the line—and one which is receiving special consideration by this department as well as by all of the interested States.

OTHER IMPORTANT MEASURES FOR REDUCING THE INFECTED AREA.

The first and probably the most important step in eradicating the cattle tick is to start and continue a plan of educating the cattle owner as to the nature of Texas fever and the method of its transmission. This may be best accomplished through farmers' institutes, the issuance of press bulletins and circulars, the publication of short articles in agricultural journals, and, best of all, by personal intercourse between the agricultural population and stock inspectors who are capable of imparting the necessary information. There can be no doubt that the crying need of the infected country is not so much the development of new ideas for exterminating the cattle tick as it is to remove all doubts of stockmen regarding what they term the "tick theory," and to impress upon them the fundamental truths concerning the cattle tick, its relation to Texas fever, and simple methods for its extermination. In some counties within the infected district the local authorities have organized cattle clubs composed of stockmen, with the view of interesting them in exterminating the ticks from their premises, and in preventing cattle in adjoining tick-infested sections from coming upon their property. These organizations are the means of disseminating general information respecting Texas-fever infestation and the cause of the restrictions placed on cattle in the infected district; and through them a concerted action of the cattle owners is obtained, resulting in the control and final eradication of the infection within a portion or the whole of a county. The success of such clubs is a constant reminder of what other organized stockmen could do.

In a number of counties in Virginia, North Carolina, and Georgia, where the laws prohibit cattle from running at large and compel fencing of pastures, the cattle tick soon disappeared, and such tick-free counties were placed above the quarantine line without any loss having followed from the cattle in these districts.

In all the infected States uniform legislation should be secured on the subject of Texas fever, by which these States would be enabled not only to cooperate with the Federal Government, but also with each other. Such laws should prevent the entrance of ticky cattle into the State, unless for slaughter, compel the holding of cattle on inclosed premises, enforce an effectual quarantine on all badly infected areas, make it compulsory to clean up the infection where the ticks are few in number, and stipulate that the stock inspectors appointed for this work must be educated and experienced in the subject of Texas fever.

It is generally admitted that extermination of ticks along the quarantine line is desirable, but the disinfection of pastures within the line is thought by some to be inadvisable. In fact, some writers recommend placing a few ticks on the cattle while young to render them immune when in tick-free pastures. This plan of infecting clean pastures is a questionable proceeding, and if carried out by all below the line would result in producing thousands of ticks where now there are hundreds only. It must be remembered in this connection that the cattle tick is not only the carrier of Texas fever, but is a parasite which deprives its host of much blood, retards growth, reduces the milking capacity, and induces an irritable state known as "tick worry." Even if we exclude its fever-carrying property, it should still be exterminated in all districts, for the same reasons that lice and other vermin are destroyed. Furthermore, cattle may now be rendered immune by blood inoculations, and the necessity for having ticks on the animals for this purpose does not exist. It would therefore seem preferable to keep noninfected farms free from ticks, and if they are in danger of exposure to these parasites make the animals immune by blood injections.

It might be asked, What advantage is it to the stockman below the line to clean his cattle and pastures of ticks unless his animals are permitted to come north without restriction? The greatly improved condition and better development in all respects of such cattle are sufficient answers to this query, and their appearance furnishes a marked contrast to that of those which harbor these parasites.

By the general application of the previously described measures for reducing the infected area, supported by well-directed legislation in all the infected districts, it would become merely a matter of a short period of time before the fever tick would be exterminated and southern cattle permitted to reach the more favorable markets of the North at any time of the year without restraint. Prices would then be higher, the demand greater, and the odium attached to ticky cattle at the stock yards removed. Purebred northern cattle could then be brought into the South to improve the native breed without danger of death from Texas fever, southern animals could enter the show rings of the North without restriction, and the total cost of tick extermination would be far less than the amount saved in the first year after it had been accomplished. However, much cooperation must be had between the farmer and the State and Federal Governments before such a desirable result is possible. And in the meantime, with such conditions attainable, laxity should not be allowed in enforcing the present regulations, national, State, and local, and equal care should be taken to enlighten the stock raisers of the infected district as to the benefits which will follow their thorough understanding of Texas fever and their intelligent assistance in its eradication.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1914